Fig. 1

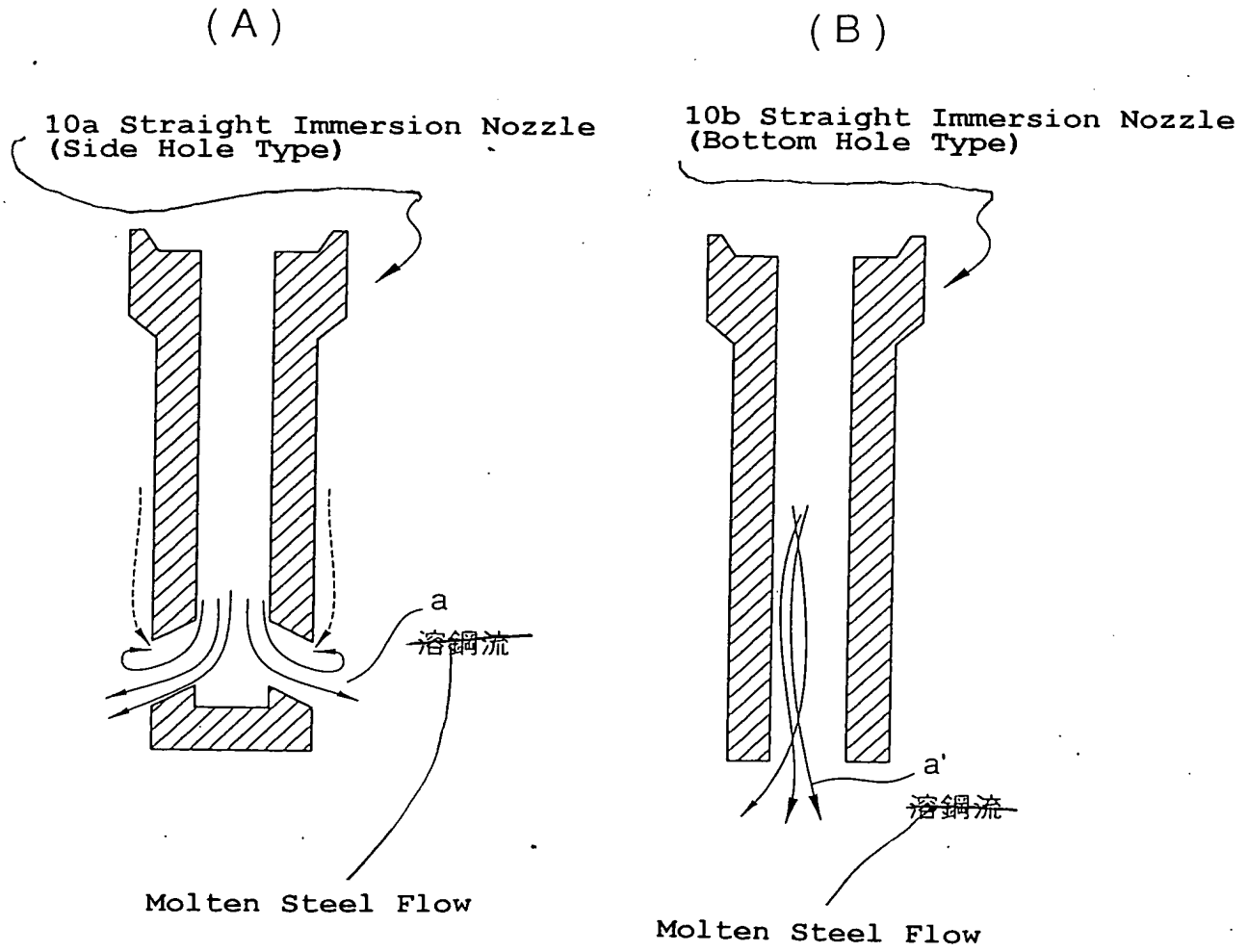


FIG. 2

		Example	
		1	2
	Diameter D (mm) of Inner Hole Portion	80	90
Protrusions	Approximate Shape	Elliptic  –	Spherical  –
	Maximum Height H (mm)	8	10
	Maximum Length L (mm) of Base Portion	32	27
	Number of disposed Protrusions	54	70
L/H		4.0	2.7
πD/L		7.9	10.5
Surface Area Increasing Rate (%)		116	114
Water Model	Degree of Drift	No	No
	Minus Flow (Presence or Absence of Suction Flow)	Absent	Absent
Actual Machine	Strength of Protrusions	OK	OK
	Deposition (mm) of Alumina on Inner Pipe	1	0
Total Evaluation		◎	◎

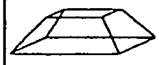
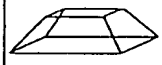
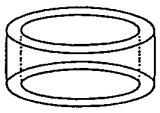
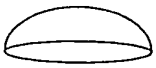
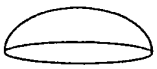
Example					
3	4	5	6	7	8
80	80	80	60	80	80
Spherical  –	Spherical  –	Conical 	Trapezoid 	Trapezoid 	Trapezoid 
2	5	10	5	15	10
10	15	22	58	31	21
60	50	90	30	230	250
5.0	3.0	2.2	11.6	2.1	2.1
25.1	16.7	11.4	3.2	8.1	12.0
102	106	115	119	345	240
No	No	No	No	No	No
Absent	Absent	Absent	Absent	Absent	Absent
OK	OK	OK	OK	OK	OK
3	1	1	0	3	0
○	◎	◎	◎	○	◎

FIG. 3

		Comparative Example	
		1	2
	Diameter D (mm) of Inner Hole Portion	80	90
Protrusions	Approximate Shape	Stepped 	Straight None
	Maximum Height H (mm)	5	-
	Maximum Length L (mm) of Base Portion	(circumferential length: 251)	-
	Number of disposed Protrusions	1	0
L/H		(50.2)	-
πD/L		1.0	-
Surface Area Increasing Rate (%)		97	100
Water Model	Degree of Drift	Middle	Large
	Minus Flow (Presence or Absence of Suction Flow)	Present	Present
Actual Machine	Strength of Protrusions	OK	-
	Deposition (mm) of Alumina on Inner Pipe	8	12
Total Evaluation		×	×

Comparative Example					
3	4	5	6	7	8
80	80	80	60	80	80
Spherical	Conical	Spherical	Spherical	Elliptic	Trapezoid
		 –	 –	 –	
10	5	1	5	2	12
8	3	10	10	3	24
50	50	50	50	80	350
0.8	0.6	10.0	2.0	1.5	2.0
31.4	83.7	25.1	25.1	83.7	10.5
115	103	102	104	101	364
No	No	Large	Small	Middle	Small
Absent	Absent	Present	Absent	Present	Present
NG	NG	OK	NG	NG	OK
6	6	10	5	6	7
×	×	×	×	×	×

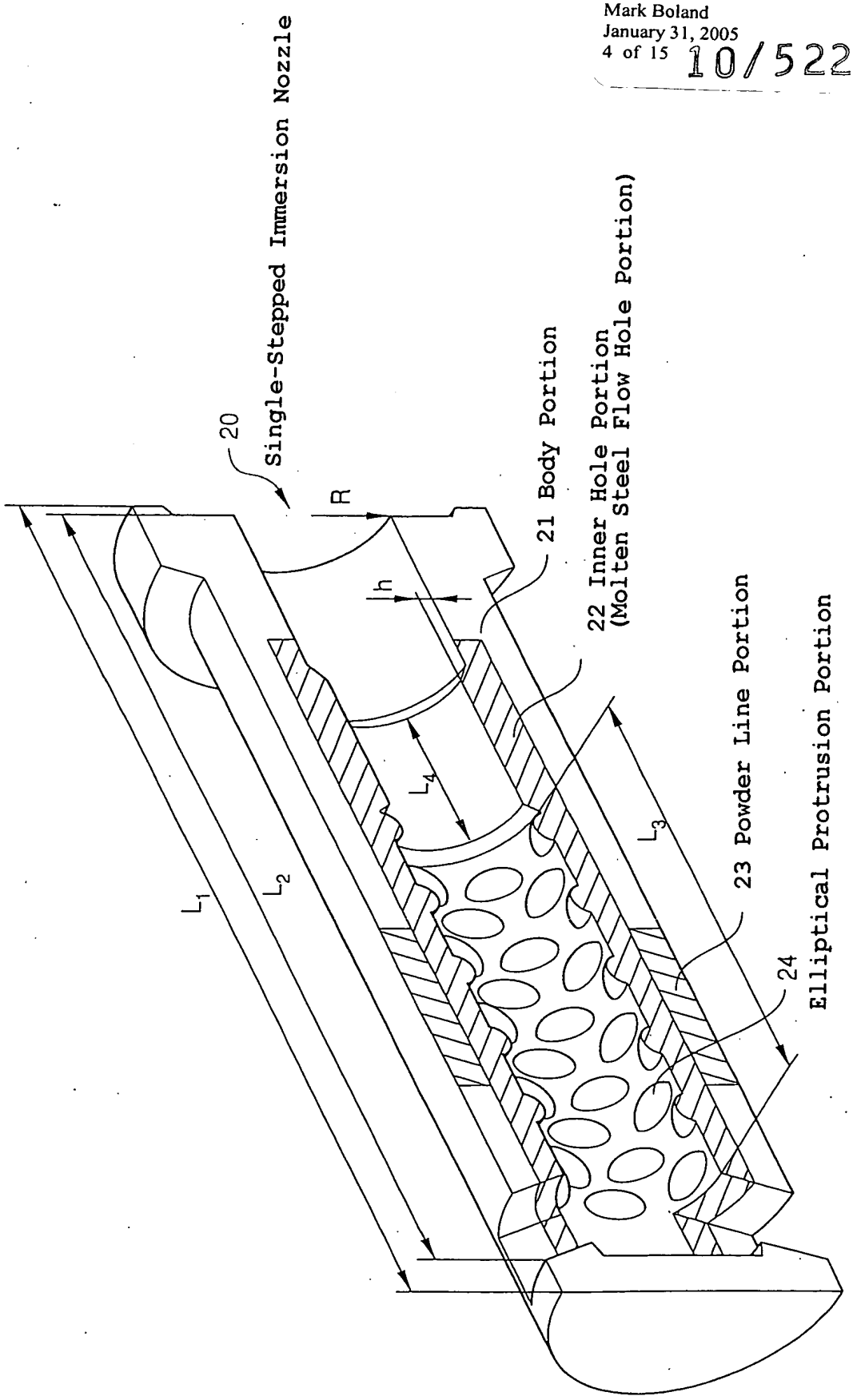

20
Single-Stepped Immersion Nozzle
R
h
21 Body Portion
22 Inner Hole Portion
(Molten Steel Flow Hole Portion)
L_1
L_2
L_3
L_4
23 Powder Line Portion
24
Elliptical Protrusion Portion

Fig. 4

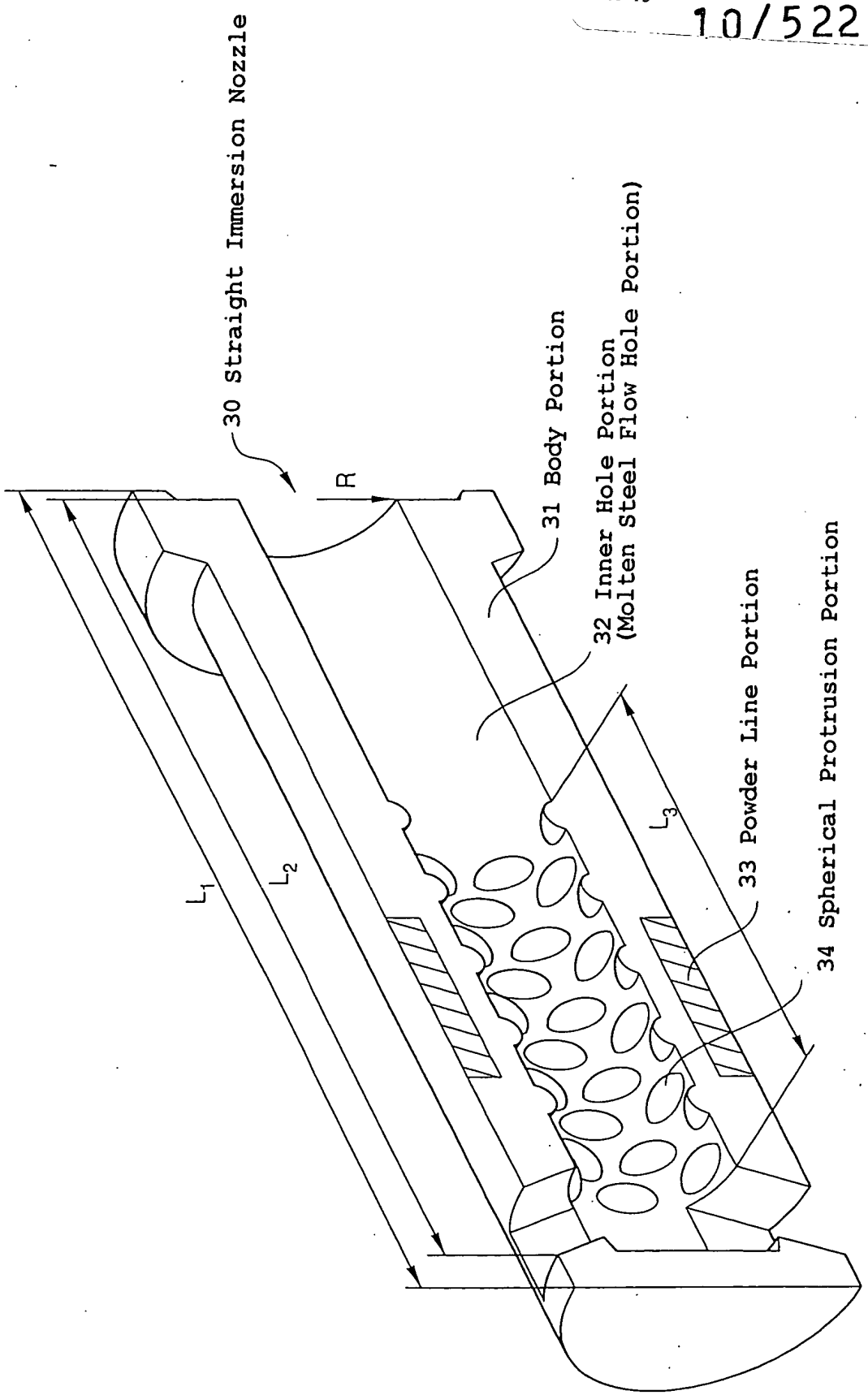

30 Straight Immersion Nozzle
R
31 Body Portion
32 Inner Hole Portion
(Molten Steel Flow Hole Portion)
33 Powder Line Portion
34 Spherical Protrusion Portion
L_1
L_2
L_3

Fig. 5

Fig. 6

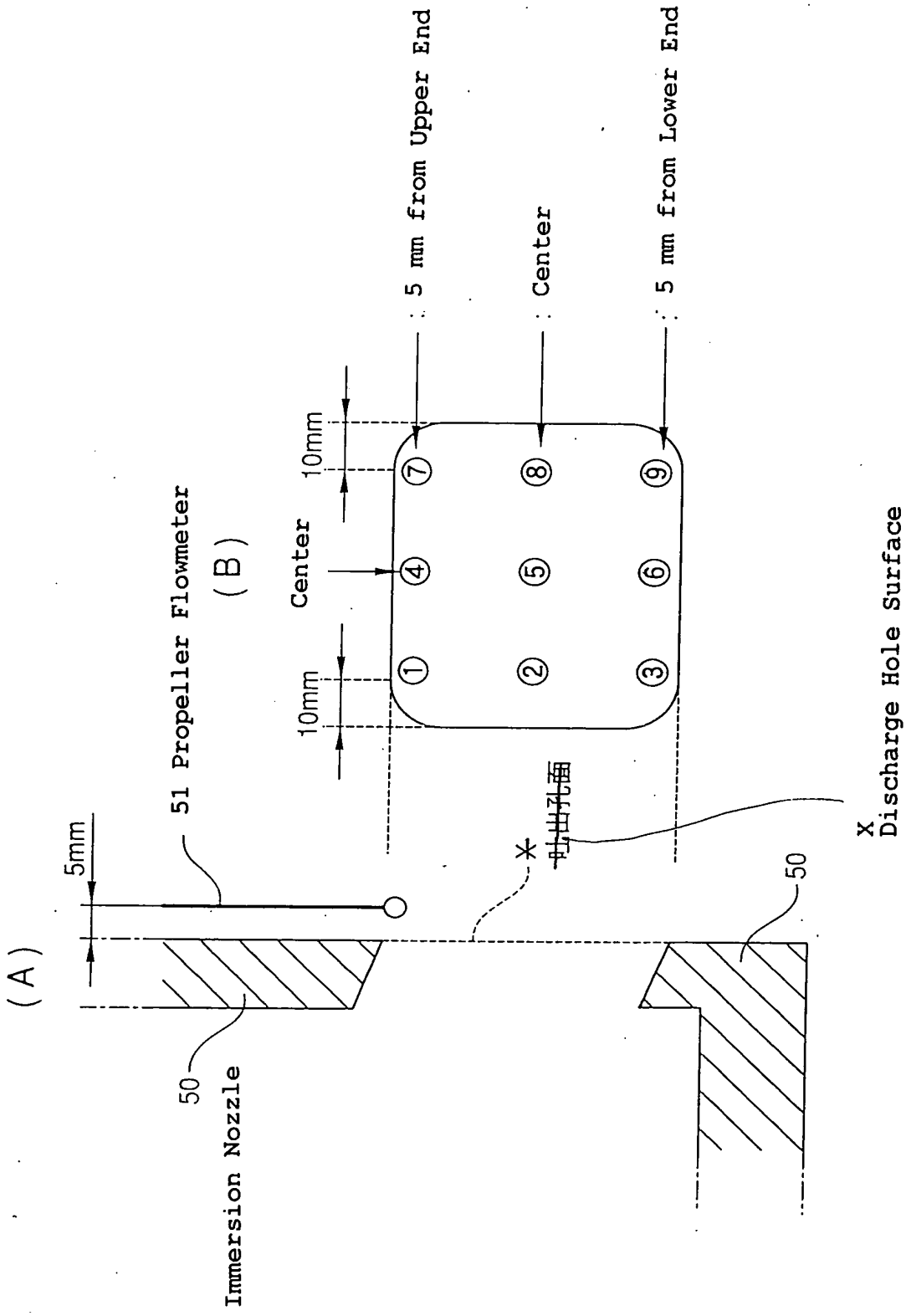

(A)
5mm
51 Propeller Flowmeter
50
Immersion Nozzle
(B)
Center
10mm
10mm
: 5 mm from Upper End
: Center
: 5 mm from Lower End
①
②
③
④
⑤
⑥
⑦
⑧
⑨
X
Discharge Hole Surface
50

FIG. 7

(A)

[Immersion Nozzle according to Comparative Example 1]

[Throughput: equivalent to 3 steel T/min]

	Left			Right		
	Rear	Center	Front	Front	Center	Rear
Upper	39	3	-1	8	49	51
Center	13	16	8	41	11	3
Lower	-2	36	38	58	-9	9

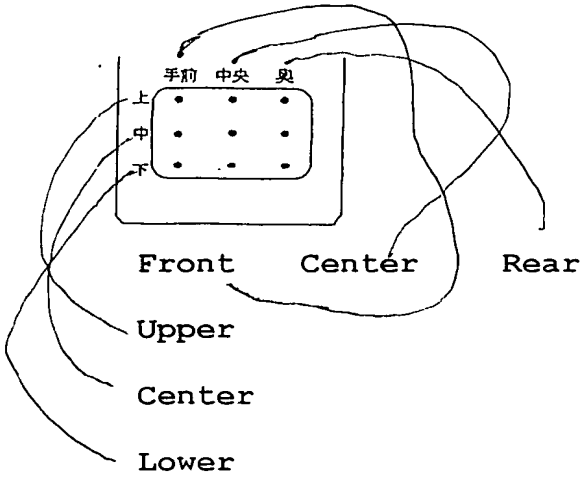
[Throughput: equivalent to 5 steel T/min]

	Left			Right		
	Rear	Center	Front	Front	Center	Rear
Upper	88	22	-6	20	83	103
Center	14	31	12	70	22	7
Lower	-18	60	68	96	-10	-1

[Throughput: equivalent to 7 steel T/min]

	Left			Right		
	Rear	Center	Front	Front	Center	Rear
Upper	102	40	0	22	97	106
Center	27	27	32	78	38	21
Lower	6	95	75	98	19	10

Flow Rate	
0>	
0-50	
50-100	
100<	



(B)

[Immersion Nozzle according to Example 1]

	Left			Right		
	Rear	Center	Front	Front	Center	Rear
Upper	3	13	18	23	20	12
Center	18	16	18	25	26	27
Lower	41	43	2	25	36	22

	Left			Right		
	Rear	Center	Front	Front	Center	Rear
Upper	41	27	16	24	39	55
Center	11	21	36	39	32	22
Lower	15	77	41	62	52	12

	Left			Right		
	Rear	Center	Front	Front	Center	Rear
Upper	122	59	26	37	62	98
Center	32	32	38	63	60	42
Lower	55	66	62	98	43	29

Fig. 8

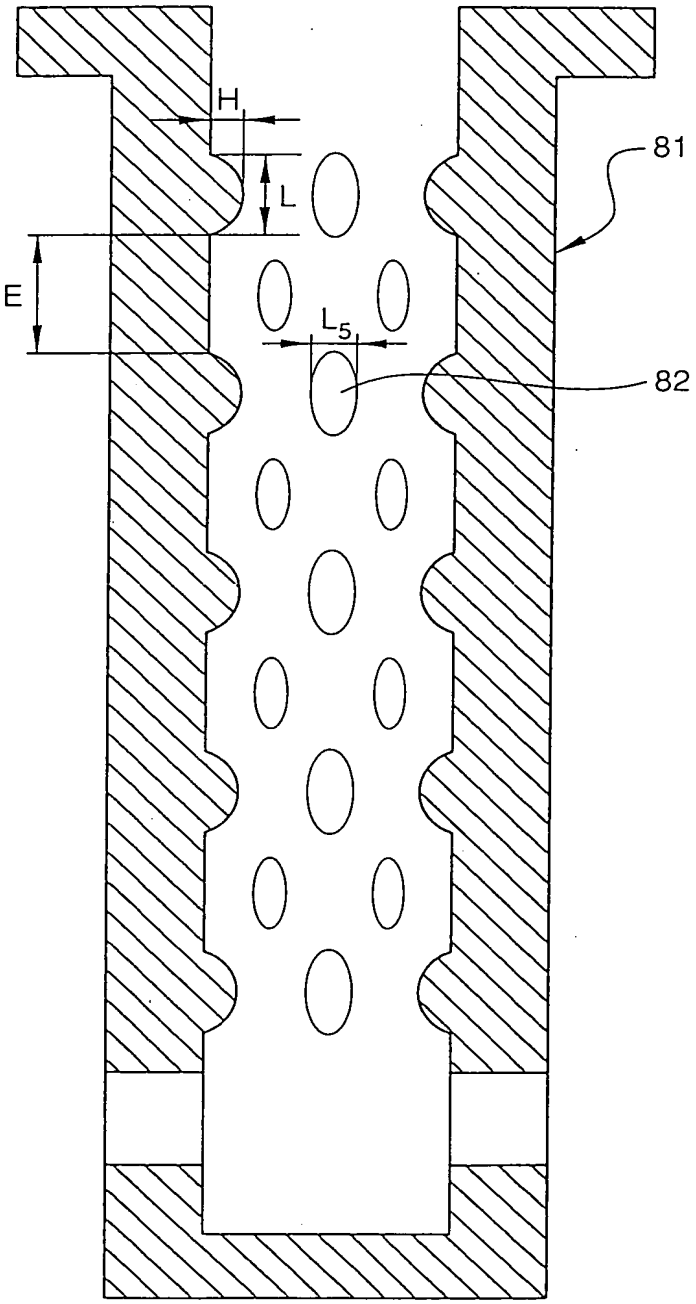


Fig. 9

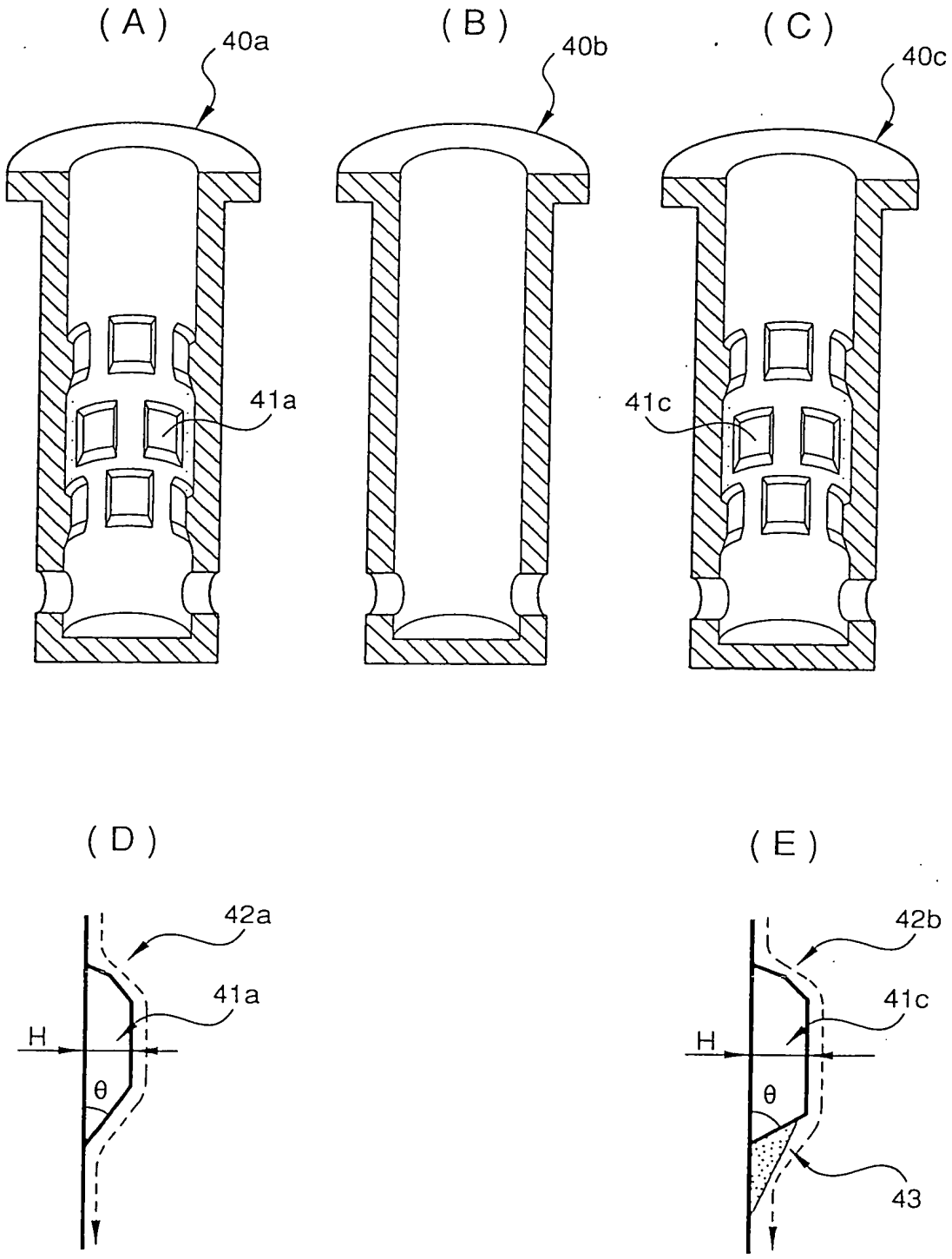


Fig. 10

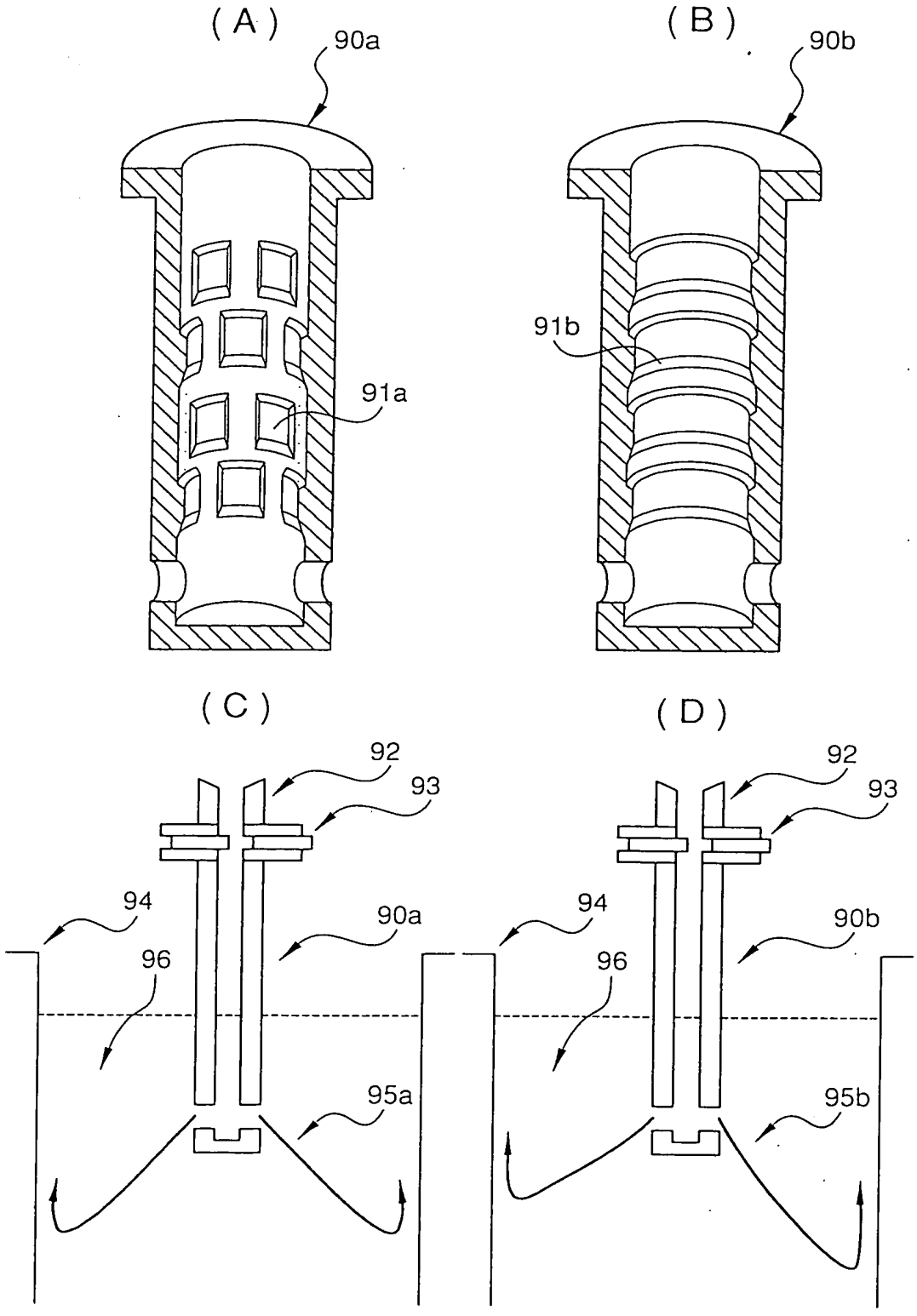
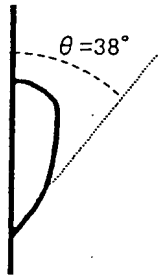
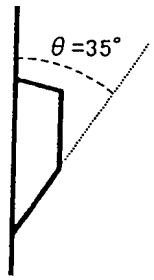
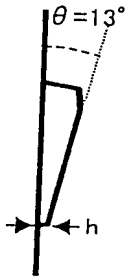
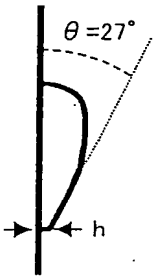
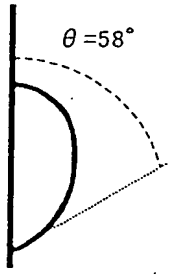


FIG. 11

	Example				
	12	13	14	15	16
Sectional Shape of Protrusion Portion					
Presence or Absence of Stagnation just under Protrusion	Absent	Absent	Absent	Absent	Absent
Straightening Effect	Good	Good	Good	Good	Good

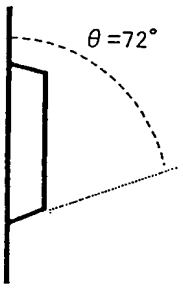
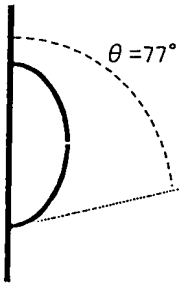
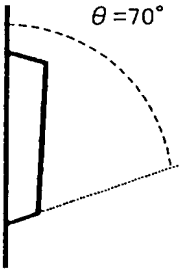
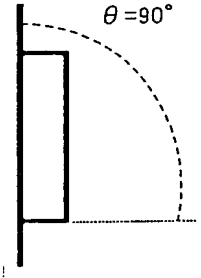
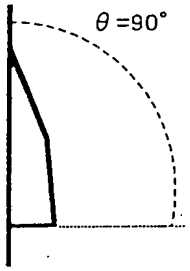
	Comparative Example				
	14	15	16	17	18
Sectional Shape of Protrusion Portion					
Presence or Absence of Stagnation just under Protrusion	Present	Present	Present	Present	Present
Straightening Effect	Bad	Bad	Bad	Bad	Bad

Fig. 12

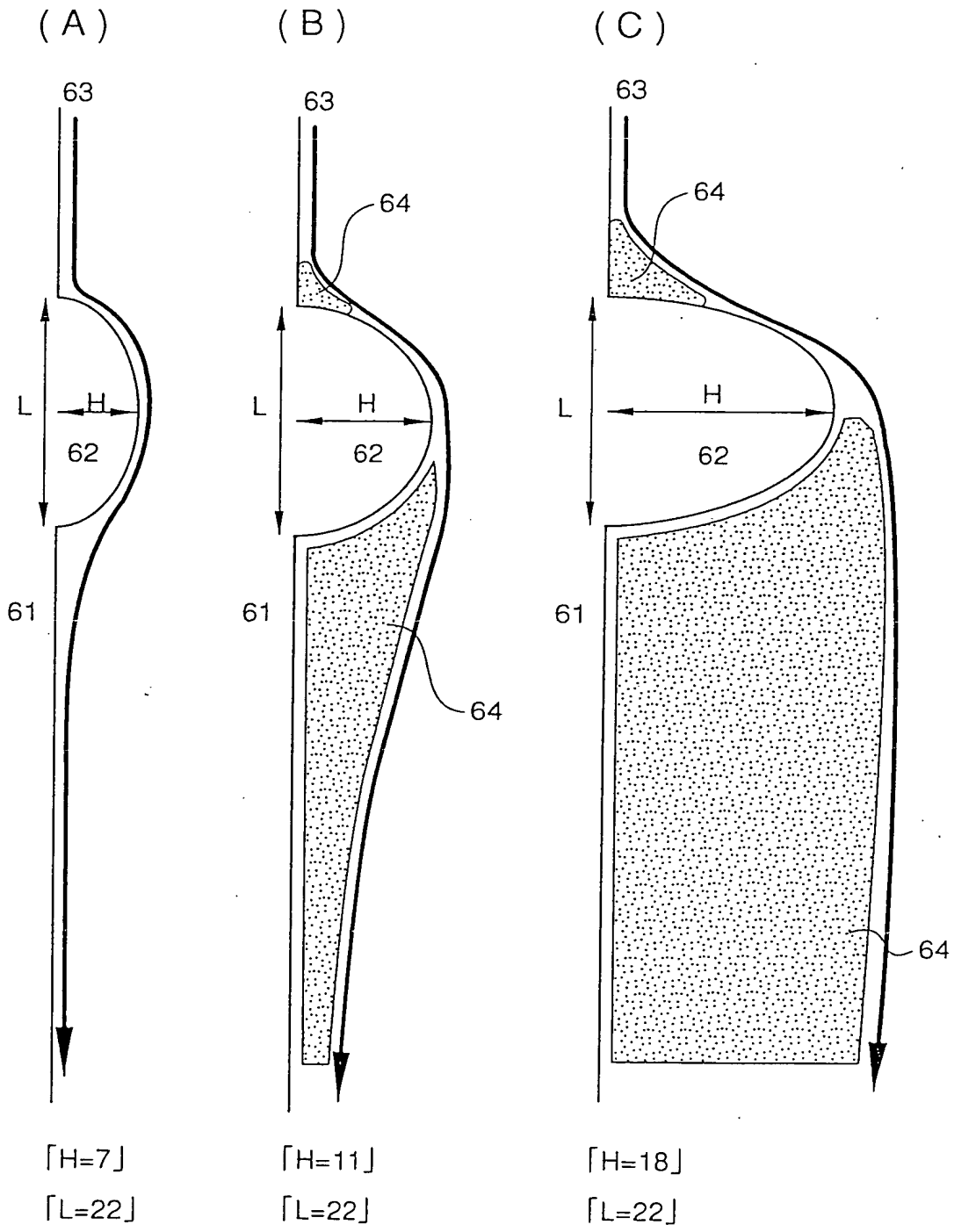
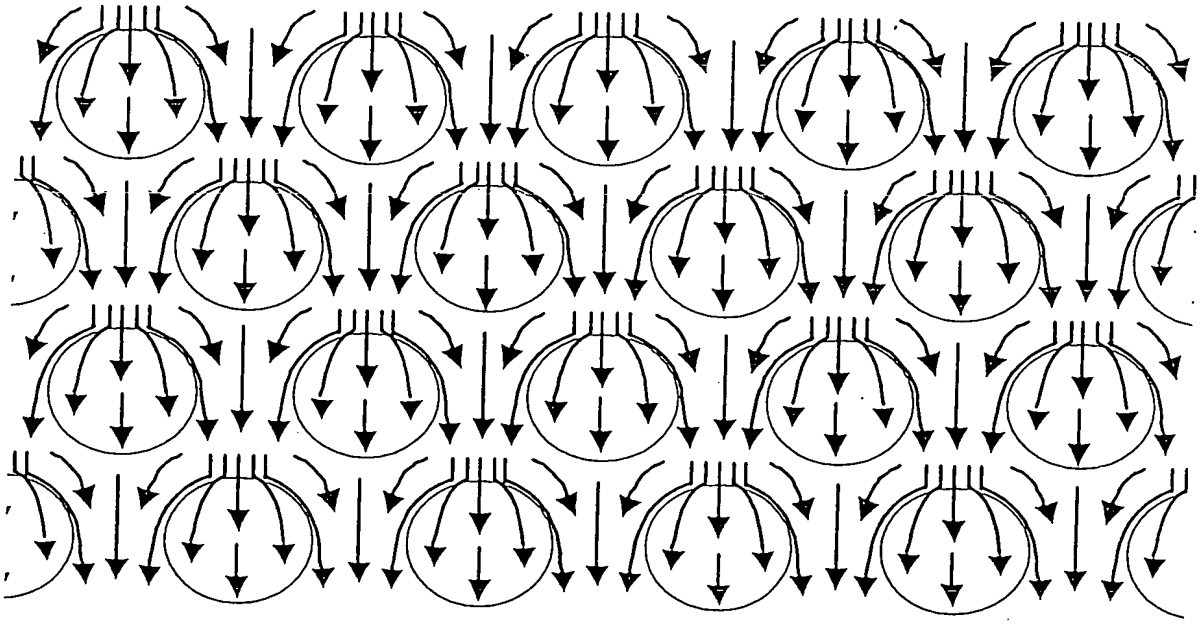
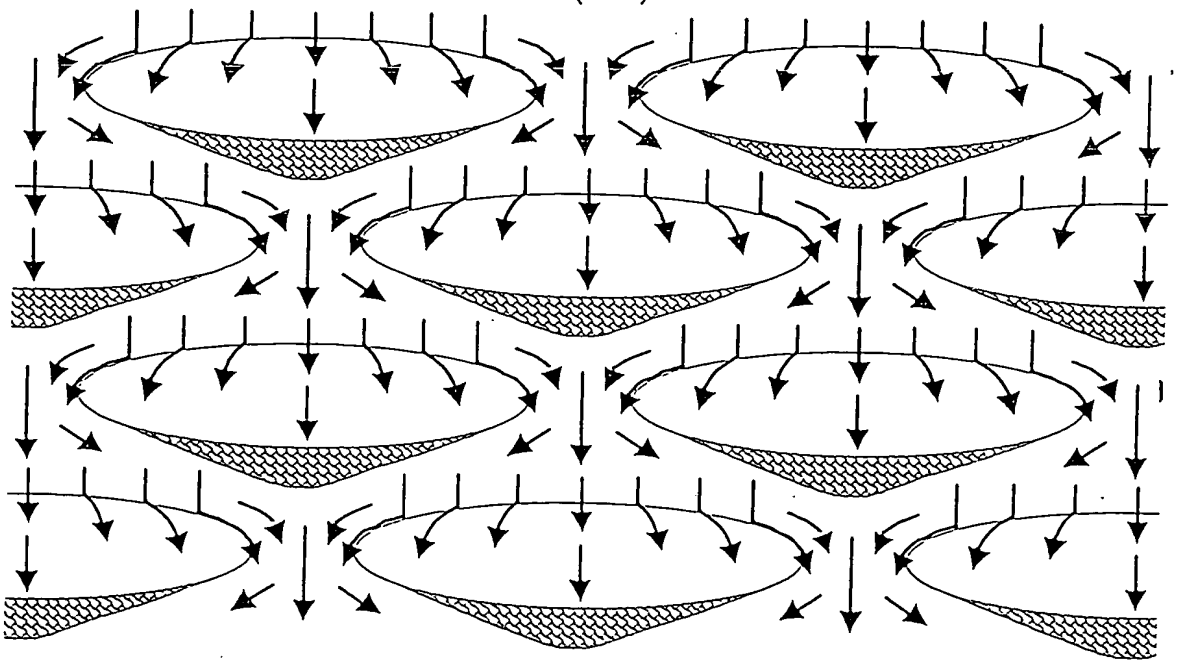


Fig. 13

(A)



(B)



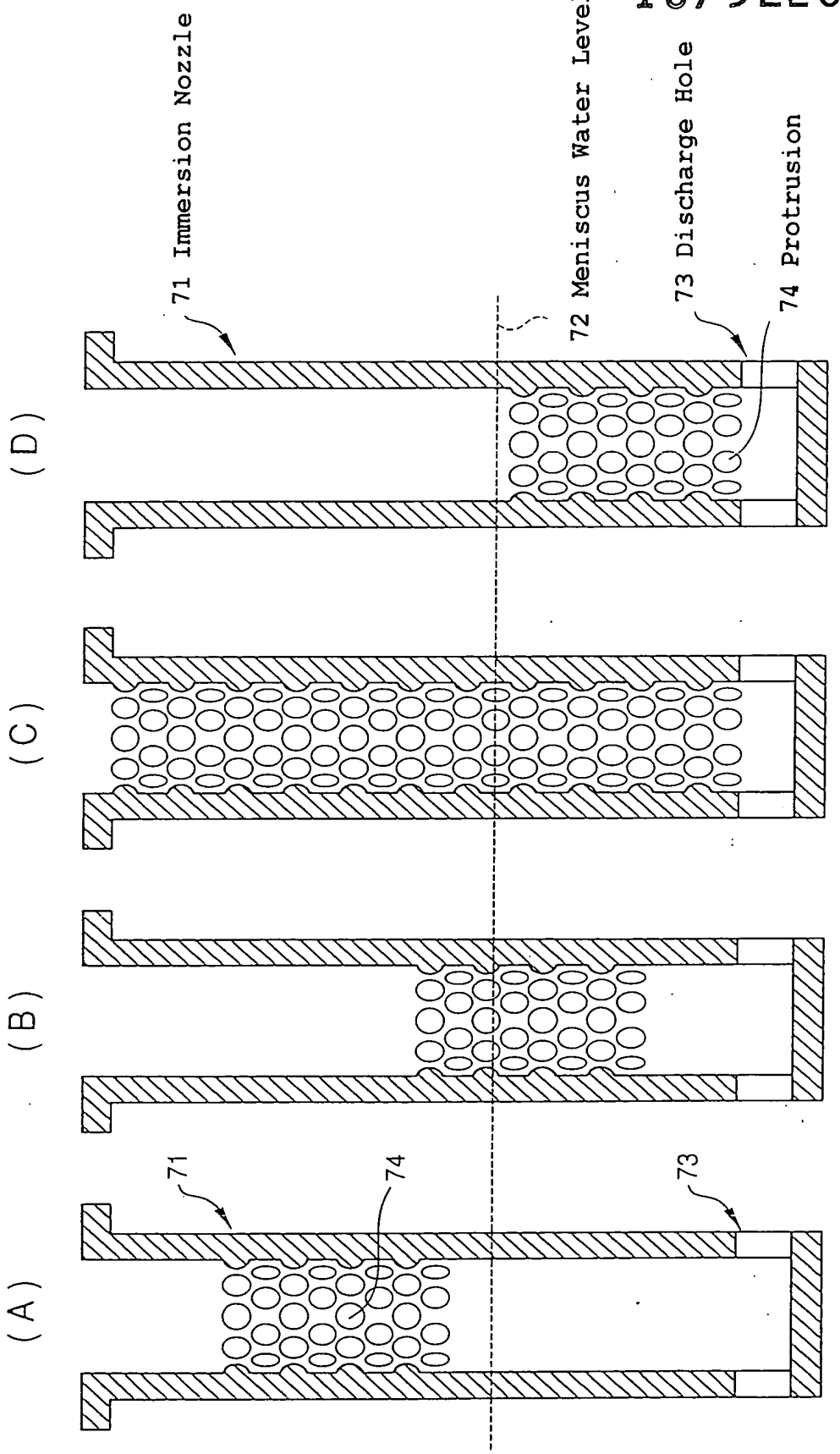

71 Immersion Nozzle
72 Meniscus Water Level
73 Discharge Hole
74 Protrusion
(D)
(C)
(B)
(A)
71
74
73

Fig. 14